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Jun 2005
...· D. K. Borah and S. Horan, ``Performance Study of Enhanced **FQPSK** and Constrained Envelope Modulation Techniques,'' Proc. International...this study. In Table 2, we list the optimal frame size, the **average** time to complete a file transfer and the standard deviation...
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...Modulation Techniques: QPSK, DPSK, **FQPSK**, QAM, M-QAM, OFDM, Optimum...for Band-limited Channels, **Viterbi** decoding. Communication through...of India, 2004. Andrew J. **Viterbi** , "CDMA: Principles of Spread...I performance improvements, **Average** P e , performance improvement...
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...can be implemented using the **Viterbi** Algorithm (VA) [8] with M L...4Eb ) d2min) (9) where is the **average** number of signals at distance...Simon and T.-Y. Yan, "Unfiltered **FQPSK**: Another interpretation and...power/bandwidth efficient coded **FQPSK** system with iterative decod...
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...Techniques: QPSK, DPSK, **FQPSK**, QAM, M-QAM, OFDM, Optimum...Band-limited Channels, **Viterbi** decoding. Communication...India, 2004. Andrew J. **Viterbi** , "CDMA: Principles...performance improvements, **Average** P e , performance improvement...Distance properties, **Viterbi** Decoding Algorithm for...
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...techniques: Concepts of Diversity branch and signal paths, Combining and switching methods, C/N, C/I performance improvements, **Average** P e , performance improvement, RAKE receiver. Cellular concept: Frequency reuse, channel assignment strategies, handoff strategies...
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# Consultative Committee for Space Data Systems

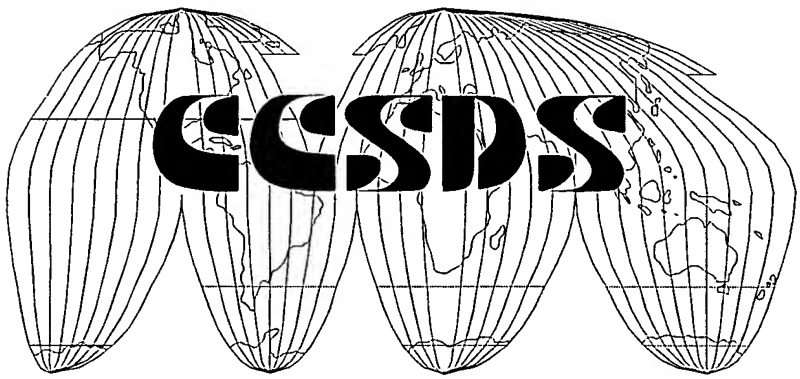
**RECOMMENDATIONS FOR SPACE DATA SYSTEM STANDARDS**

# RADIO FREQUENCY AND MODULATION SYSTEMS—

## PART 1
## EARTH STATIONS AND SPACECRAFT

**CCSDS 401.0-B**

**BLUE BOOK**



## 2.4.17A MODULATION METHODS FOR HIGH SYMBOL RATE TRANSMISSIONS, SPACE RESEARCH, SPACE-TO-EARTH, CATEGORY A

**The CCSDS,**

**considering**

(a) that efficient use of RF spectrum resources is imperative with the increasing congestion of the frequency bands;

(b) that the SFCG has approved a Recommendation,[1] specifying a spectrum mask for *Space Research* Category A Space-to-Earth links operating in certain bands;[2]

(c) that suppressed carrier modulation techniques, such as FQPSK-B,[3] GMSK[4] and baseband filtered/shaped OQPSK[5] modulations, can meet the SFCG Recommended[1] spectrum mask for symbol rates in excess of 2 Msps;

(d) that FQPSK-B,[3] GMSK[4] and baseband filtered/shaped OQPSK[5] modulation types can be demodulated using a conventional OQPSK receiver, but with differing end-to-end losses;

(e) that GMSK,[4] baseband filtered OQPSK[5] and, with proper trellis demodulation/equalisation techniques, FQPSK-B[3] and shaped OQPSK[5] modulations have only a small performance degradation as compared with ideal unfiltered suppressed carrier systems;

(f) that most space agencies currently have conventional OQPSK receivers and many have no plans to modify their existing OQPSK ground station receivers to optimise reception of FQPSK-B,[3] and GMSK[4] signals, so that these two modulation techniques will incur greater losses than filtered OQPSK;[5]

(g) that the link performance of FQPSK-B[3] modulation exhibits greater losses than GMSK;[4]

(h) that FQPSK-B, GMSK and baseband filtered/shaped OQPSK modulations have immunity to interference (wideband and narrow band) comparable to unfiltered BPSK when demodulated with a OQPSK receiver matched to an unfiltered OQPSK waveform; the interference immunity of these modulations when demodulated with matched filter receivers is equivalent to or better than BPSK;

**recommends**[6]

that, to comply with the SFCG Recommendation[1] and to ensure an ability to obtain cross-support in certain *Space Research* service bands[2] FQPSK-B,[3] or GMSK[4] or baseband filtered/shaped OQPSK[5] be used for Space-to-Earth transmissions when the telemetry data symbol rates exceed 2 Msps.

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NOTES:

1 See SFCG Recommendation 17-2R1 or latest version.

2 Category A bands are: 2200-2290 MHz and 8450-8500 MHz.

3 Feher-patented Quadrature Phase Shift Keying modulation. For further information, contact DIGCOM Inc, El Macero, Ca, USA.

4 Gaussian Minimum Shift Keying ($BT_B = 0.25$), with pre-coding see CCSDS 413.0-G-1).

5 Filtered (Square Root Raised Cosine $\alpha = 0.5$) Offset QPSK; Butterworth 6 poles, $BT_B = 0.5$ or Shaped Offset QPSK-A, -B; agencies may also utilise baseband-filtered OQPSK modulation with other types of filters provided that they ensure compliance with note 1 above and interoperability with the cross-supporting networks.

6 Space agencies requiring cross-support should consider the performance degradation of the filtered/shaped OQPSK, GMSK, and FQPSK modulation techniques when received with unmatched demodulators at existing ground stations (see performance data in CCSDS 413.0-G-1); the ordering of modulation types does not imply a preference.

## 2.4.17A MODULATION METHODS FOR HIGH SYMBOL RATE TRANSMISSIONS, SPACE RESEARCH, SPACE-TO-EARTH, CATEGORY A

**The CCSDS,**

**considering**

(a) that efficient use of RF spectrum resources is imperative with the increasing congestion of the frequency bands;

(b) that the SFCG has approved a Recommendation,[1] specifying a spectrum mask for *Space Research* Category A Space-to-Earth links operating in certain bands;[2]

(c) that suppressed carrier modulation techniques, such as FQPSK-B,[3] GMSK[4] and baseband filtered/shaped OQPSK[5] modulations, can meet the SFCG Recommended[1] spectrum mask for symbol rates in excess of 2 Msps;

(d) that FQPSK-B,[3] GMSK[4] and baseband filtered/shaped OQPSK[5] modulation types can be demodulated using a conventional OQPSK receiver, but with differing end-to-end losses;

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(g) that the link performance of FQPSK-B[3] modulation exhibits greater losses than GMSK;[4]

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that, to comply with the SFCG Recommendation[1] and to ensure an ability to obtain cross-support in certain *Space Research* service bands[2] FQPSK-B,[3] or GMSK[4] or baseband filtered/shaped OQPSK[5] be used for Space-to-Earth transmissions when the telemetry data symbol rates exceed 2 Msps.

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NOTES:

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2 Category A bands are: 2200-2290 MHz and 8450-8500 MHz.

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# AUTHORITY

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This document has been approved for publication by the Management Council of the Consultative Committee for Space Data Systems (CCSDS) and represents the consensus technical agreement of the participating CCSDS Member Agencies. The procedure for review and authorization of CCSDS Recommendations is detailed in Reference [1] and the record of Agency participation in the authorization of this document can be obtained from the CCSDS Secretariat at the address below.

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